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# The Teaching/Research Nexus And Internationalisation: An Action Research Project In Radiation Physics

This paper attempts to unpack the teaching and learning experiences of academics and students when a new way of teaching radiation physics was introduced. In an attempt to articulate the University of Wollongong's commitment to the enhancement of the teaching/research nexus and to the development of learning communities, staff of the School of Physics in the Faculty of Engineering at University of Wollongong (UOW) implemented an action research project teaching scientific computing methodologies used in radiation physics to a combined laboratory class of postgraduates and undergraduates. The design of the practical laboratory classes took account of the expected heterogeneous computing skills and different knowledge of radiation physics of undergraduate and postgraduate students. Based on an earlier study, it was presumed that postgraduate students would be in a good position to support undergraduates. We illustrate how broad-based conceptions of the value of learning communities and their role in fostering the teaching/research nexus may be challenged by an internationalised student body. In this case, the previous patterns of undergraduate and postgraduate enrolments, which the pilot study had canvassed, did not hold true; almost all of the postgraduate students were international students, only recently arrived in Australia. This, along with other factors, meant that learning outcomes and students' responses to the innovation were not what were expected. We suggest a path forward, both for the specific subject in which the innovation occurred, and for other similar attempts to bring together academics, postgraduate and undergraduate students in a nascent learning community, in the light of ongoing trends towards internationalisation.

**Keywords** - teaching/research nexus, radiation physics, Monte Carlo simulation, undergraduate/postgraduate education, internationalisation

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## **Introduction**

Research universities are described as being archipelagos of intellectual pursuit, rather than connected and integrated communities. Many studies suggest there is an inverse relationship between research productivity and teaching quality and the nexus between research and teaching is an article of faith, rather than a phenomenon for which we have evidence (Kenny, 1998; Pascarella and Terenzini, 2005; Yang, 2002). To address these types of discrepancies, the model the Boyer Commission proposed includes scholar-teachers treating their research sites as seminar spaces open to graduate and undergraduate students, where, regardless of academic level, all can practice their research skills and help develop others' proficiency; students perform their understanding, rather than just declaring it (Biggs, 2007). A report by Gabrielle Baldwin (2005) for the University of Melbourne suggests nine approaches for building the teaching/research nexus beyond an article of faith, including drawing on personal research in designing and teaching courses; building small-scale research activities into undergraduate assignments; encouraging students to feel part of the research culture of departments; and conducting and drawing on research into student learning to make-evidence-based decisions about teaching (Baldwin, 2005, p. 4).

In an attempt to build a connected and integrated community based on these approaches and led by scholar-teachers, lecturers at the School of Physics of the University of Wollongong (UOW), with the support of the Head of School, implemented a hands-on computing laboratory, to teach modern, advanced research tools for radiation physics and scientific computing methodologies to a combined class of undergraduate and postgraduate students (Guatelli *et al.*, 2010). In brief, Geant4 is a widely used (Monte Carlo) simulation toolkit describing the interactions of particles with matter (Agostinelli, 2003; Allison, 2006). It adopts object-oriented technology, and it is implemented in C++ programming language. It is developed, maintained, and upgraded through international collaboration, spanning the US, Europe, Asia and Australia.

While the Geant4 Collaboration organizes courses and seminars around the world to familiarise researchers and postgraduates with the Geant4 Simulation Toolkit, little attention is paid to undergraduates. The common practice is to delegate the teaching of scientific computing tools to research centres, where students work on their Honours/Masters/PhD thesis separate from the everyday learning and teaching environment. In contrast, we were interested in introducing students to advanced research tools earlier in their university career (Kenny, 1998; Trowler and Wareham, 2007), both as a means of fostering the use of the lecturers' research sites as seminar spaces (Biggs, 2007), and to build bridges between undergraduate and postgraduate studies and students.

At the Centre for Medical Radiation Physics (CMRP), approximately forty students (Masters/Honours and PhD) each year work on their thesis project, with approximately one third of them using Geant4 as the simulation toolkit in their research.

In this instance, radiation physics practice was seen as the frame for the curriculum. Broad access to mature practice, with lecturers, tutors, postgraduate and undergraduate students working alongside each other on set problems, would provide opportunities for self-evaluation without tests, praise or blame; talk within practice (sharing information that progressed activities) and talk about practice would engage and focus attention, engender coordination, support reflection, and signal membership of a research community (Lave and Wenger, 1991). Based on these assumptions, on Geant4 Collaboration hands-on courses for researchers, on Boyer's ideas about fostering the teaching/research nexus, and on a small study undertaken in 2009 at CMRP about students' learning needs, a combined postgraduate/undergraduate laboratory was introduced in Autumn session 2010 (March-June 2010). The curriculum incorporated the following:

- pairing postgraduate and undergraduate students as they undertook laboratory work;
- intensive support from academic staff for students during laboratories;
- identifying aspects of Geant4 that require formal teaching, and incorporating these in seminars that interspersed with laboratory work; and
- elaboration of a scientific report, as final summative assessment, describing the articulation of the project developed within the Geant4 hands-on laboratory.

Using an action research process, the implementation of this novel approach was carefully monitored by a team composed of three academics and an academic developer. Internationalisation processes at UOW became an issue: unexpectedly almost the entire cohort of postgraduate students was composed of newcomers from overseas. This paper outlines the problems we encountered, how we dealt with them, whether or not these solutions were effective, and how we think further iterations of this type of innovation might proceed.

## **Methodology**

Our new approach to developing the research skills of undergraduates alongside more experienced students and active researchers was developed using an action research process (Kemmis and McTaggart, 1988; Mcfarland and Stansell, 1993, p. 10). Action research is not a ‘method’ or ‘procedure’ for research, but a series of commitments to observe and problematise practice in the light of the principles of social enquiry (McTaggart, 1996, p. 248). It involves a cyclical process of observation, problem posing, data gathering, reflecting, planning and implementing actions – a search to improve practice rather than solve a problem. As such, this is largely an interpretive endeavour, in which students’ voices and the ongoing observations of the lecturers play a significant role.

## **Designing the new subject**

During the hands-on course, students develop a simplified Geant4-based dosimetric system for brachytherapy, through a series of exercises, as proposed in (Guatelli, 2010). Brachytherapy is a radiation therapy treatment for prostate, cervix, uterus, and skin cancer (Baltas, Sakelliou, and Zamboglou, 2007). Radioactive sources are set directly in the tumour region, or in its proximity, delivering the required dose to the cancer, and preserving the surrounding healthy tissue.

Theoretical seminars on Geant4 are not as successful as hands-on courses, as the content of the seminar is usually too complex for non-computing experts. A survey conducted at CMRP in 2009 had revealed that students starting their Masters/Honours thesis generally lacked a computing background suited to scientific research, and found it very hard to start working with Geant4. Amongst PhD students, there was more heterogeneity in scientific computing knowledge (from low to highly qualified), and, independent of their computing background, students encountered fewer obstacles in learning to use Geant4. Nonetheless, the findings stressed that, even if Geant4 is developed for use by those with no computing expertise, students will have considerable difficulty in starting to use it as simulation toolkit.

The survey highlighted the need to teach the methodology associated with the proper use of advanced simulation tools for radiation physics. In our experience, students encounter more difficulties in learning Monte Carlo codes at the very beginning, when they need (1) to grasp the basic knowledge, to get a global vision of the structure of the Monte Carlo code kernel, and (2) to learn how to set-up a specific simulation application. In this early stage, students are

quicker in their learning process if they are closely supervised by a Monte Carlo expert. Our previous experience with Honours/Masters students indicated that one expert is necessary to follow a maximum of five working groups effectively, as the exercise sessions require deep involvement of the staff to support students in their learning process. Once students have broken the ice, the learning process speeds up considerably, and requires no close expert supervision.

In the newly designed program, practical computing sessions were interlaced with seminars providing the fundamental introduction to Geant4 and to the hands-on course, supported by discussion sessions and at-home practice. We worked from the premise that teacher control is best suited to in-depth topics, where misconceptions can be corrected; peer control is useful for elaborating and broadening understanding, and generating self-insights (Biggs, 2007, p. 79). There were four three-hour Geant4 hands-on sessions, and, at the end of the course, students completed a report. The core of the learning process of Geant4 was the hands-on practical computing activity, where students were required to develop the simulation code, under the strict supervision, and with the support, of Geant4 tutors.

Undergraduate and postgraduate students were allocated partners in order to ensure everyone had similar levels of knowledge of radiation physics available to them, even though this ran the risk of having the postgraduate students as leaders and primary actors. However, it was expected that, by working with others who had experience and skill, and sharing in real undertakings in which there was a clear relationship between means and consequences (Dewey, 1966, p. 150), the undergraduate students would become more engaged with their studies, develop a vision of the future, and be more challenged to do their best (Chen and Darst, 2001).

Situated learning studies have shown that the social processes associated with active engagement are most important for assisting novices with tasks, for resolving problems, and for building an image of possible futures (Wenger, 1998; Billett, 1994). Lave and Wenger (1991), and Billett (2001, 1999) emphasise access to practice over instruction as a resource for learning, and the joint provision of models and cues; the need for learners to do the thinking, and to receive direct guidance from credible experts. We believed we would achieve all of these through building in regular feedback and discussion with students, as well as assessment processes that clearly linked to the work-related activities they were undertaking.

## **The action research process**

In terms of monitoring the process as it evolved, at the end of each laboratory session there was an open discussion among students and laboratory staff, with a critical analysis of the achievements, results, obstacles experienced, and the methods adopted in solving the exercises. In our experience, it is in this part of the course where the most interesting questions and ideas from students arise, and where more in depth information and important reflections take place. Student feedback would also significantly help the laboratory coordinator to check any emergent issues intrinsic to the new course design, such as the inefficient organisation of time schedules, the wrong level of difficulty of the computing exercises, and inappropriate teaching strategies employed by the laboratory coordinator and tutors. Student feedback was also seen as an important way to identify any unbalanced working groups.

In addition to this discussion, specific feedback on a limited range of issues was also sought at the end of three laboratory sessions, using a range of informal feedback tools, initially drawn from Angelo and Cross (1993) and Habeshaw, Gibbs and Habeshaw (1992), but later directly related to lecturer observations of what was happening. These feedback mechanisms addressed, firstly, what students had understood or found difficult to understand; secondly, how they were responding to being paired with a student with whom they were unfamiliar; and thirdly, how their views of themselves and their future participation in radiation physics had changed.

After each session, teachers met to discuss how best to proceed, and the data from the feedback forms was analysed. Students' comments were collapsed into summary tables in an effort to discern any trends; owing to the low numbers of students in the study, no statistical analyses were undertaken. In addition to these peer and student feedback mechanisms, the subject coordinator kept a journal tracking her own and students' responses to the laboratory exercises and teaching processes.

## **The encounter with Geant4**

### ***Student demographics***

Of the 21 students involved in this trial, 10 students were studying at the postgraduate level, and 11 were undergraduates. All of the undergraduate students were Australian, and already knew each other; of the ten postgraduate students, four were from Saudi Arabia, two from China, two from Australia and one each from Iran and India.



The teaching staff were supported by three PhD candidate volunteers of CMRP, experts in Geant4, who were interested in the development of a learning community and in gaining experience as tutors. Two volunteers helped during the first laboratory session, the third one in the last two labs.

This distribution meant that the anticipated matching of undergraduate/postgraduate students was not fully implemented, and that the undergraduate and postgraduate students had very different backgrounds and relationships within and beyond the classroom. Some language difficulties were likely amongst postgraduates. Furthermore, the smaller than anticipated number of students meant that, in analysing the data, we could only make tentative assertions about what occurred, and what the implications might be for subsequent iterations of this subject or in similar situations.

### ***The first laboratory***

The first laboratory was in two parts: seminars and exercises on (1) Monte Carlo simulation method, and (2) Geant4 and how it is used to solve problems in physics and in medical physics. The very first, preliminary exercise (in part 1) consisted of calculating the  $\pi$  value using the Monte Carlo method, to understand and appreciate its core mathematical concepts, by means of a simple simulation code, independent of possible difficulties deriving from the adoption of Geant4. Then the hands-on course took off with the Geant4 exercises.

At the beginning of the course, the students were taught how to log in to their account on the CMRP scientific cluster, and were instructed in basic Linux commands, to access directories and edit files. Students were provided with a dummy Geant4 simulation application. In the first exercise, the students needed to learn how to compile and execute this dummy application, using the simulation user interface commands. They would also become familiar with the way in which plotting and analysis of results is executed by means of ROOT (<http://root.cern.ch/drupal/>).

Students appeared very interested, and understood the Monte Carlo method and why it was important for medical physics. However, it soon became apparent that all of the students were in difficulty. The main issue at this point was that the undergraduate students, in particular, lacked any prior experience in the use of Linux platform (<http://www.linux.org/>) and C++ language, and several of the postgraduate students were similarly handicapped. Without a basic grasp of the program, everything about Geant4 became mysterious, and lecturer, tutors and volunteers alike were run off their feet, as they supported students in attempting to compile and execute the program.

It had been decided that, for the first joint laboratory session, the feedback sought from participants would not relate directly to the innovation of having undergraduate and postgraduate students working together, but would involve a final general question that would allow any comments about this to emerge. Participants were asked four questions:

1. What is the most important thing I learned today?
2. What is the most difficult thing to understand?
3. What was the muddiest point in today's session?
4. What did you do today, how and why?

Students' responses supported the lecturers' observations (Table 1).

**Table 1: Students' views of the first laboratory**

<b>Q</b>	<b>Learning issues</b>	<b>UG (PHYS366) (n=10)</b>	<b>PG (PHYS 952 and PHYS 950) &amp; PhD (n=7)</b>
Q1	Grasp of radiotherapy principles	7	6
	Computing skills (positive)	2	4
	Computing skills (negative)	1	0
Q2	Largely coped with the programming difficulties	3	7
	Stumped by the programming difficulties	10	0
	No problems identified	0	2
Q3	Not knowing coding	3	2
	Identified need for guidance or how to address the problem	4	2
	Minor issues	0	3
	Utterly confused	3	0
	No problems reported	0	3
Q4	Grasped the overall purpose	4	2
	Learned specific concepts or skills	8	7
	Nothing gelled	1	0

In relation to Question 1, about what had been learned, undergraduates mostly mentioned their general grasp of the simulation toolkit. Postgraduates showed a greater level of appreciation at acquiring the requisite computing skills did the undergraduates.

This was borne out in the responses to Question 2, about the most difficult thing to understand, where nine postgraduates responded either that they had no problems, or largely coped, whereas the majority of undergraduates struggled. Typical comments from undergraduates were:

- Programming is hard.
- We were never taught any computer programming skills, so inputting data is hard because not only am I unfamiliar with the commands of the program, I am also lacking in programming.

Question 3 yielded very similar information to that provided for question 2, with an increase in frustration from undergraduate students:

- The code. Why do we type what we're told to?

This did not mean that all members of both groups were completely stumped; four undergraduates and two postgraduates identified their need for guidance, or made suggestions as to how to address the problems they faced. Typical comments included:

- How to actually execute some of the commands- since the class was so big, it was difficult to get help at times (UG).
- I don't understand what we are doing. A prelab reading list would have been neat (UG).
- How to actually run the program – need to go right back to basics (PG).
- Not having example files in the directory (PG).

At least one postgraduate student was very comfortable, and went exploring:

- Actually, the accounts were set up fully for my use.

Question 4 (what they had done today, how and why) was intended to allow for comments about the paired undergraduate/postgraduate learning process. None of the comments arising from question 4 related to the peer-learning context – they all related to the level of understanding of Geant4. This may have been because students were overwhelmed by their technical difficulties, or they were primed by the preceding questions to only respond in terms of content. However, some undergraduate students chose not to work in their designated pairs, meaning they were in established friendship groups, and others were working by themselves. Resistance to a long tradition of self-selected groups amongst undergraduate students may have been stronger than had been realised.

As a result of the difficulties faced by the students, extra sessions were programmed, as highlighted in Table 2.

**Table 2: Modifications to laboratory sessions following first laboratory**

I lab (3 h)	II lab (3h) Voluntary	III lab (3h)	IV lab (3 h)	V lab (3 h) Voluntary
Seminar: Introduction to Monte Carlo	Exercise: Practice basic Linux commands	Seminar: Introduction to Geant4 geometry and material modelling	Seminar: Introduction to Geant4 model of radiation fields	Write the report on the Geant4 lab
Exercise: Monte Carlo method	Exercise: Learn to run the Geant4 dummy application	Exercise: Model a radioactive source in terms of geometry	Exercise: Model the radioactive source in terms of primary particles, emitted by the radionuclide	
Seminar: Introduction to Geant4 Monte Carlo for Medical Physics			Seminar: Introction to Geant4 physics list	
Seminar: Introduction to Geant4 dummy application			Exercise: Change in the physics list the threshold of production of secondary particles and analyse the effect in the dosimetric results	
Exercise: Learn how to execute a Geant4 application				

### ***The second laboratory***

In the second laboratory, for which attendance was voluntary, students gained familiarity with the C++ computing tools. It was a very fruitful session to which almost all students came. However, the lecturer noticed that the teams did not work well – undergraduates were working with each other, and several students were working on their own.

### ***The third laboratory***

The second exercise consisted of modelling a brachytherapy radioactive source. In order to do this, students had to learn to model the materials and the geometry components of the radioactive source. Students had to verify the correct implementation of the geometry, and to use Geant4 geometry tools for debugging purposes. Students were also required to test the correct generation of primary particles.

Owing to the fact that we aimed to foster contact between undergraduate and postgraduate students, we decided that this session would include a presentation on the value of working in their allocated pairs, that students would be required to work in these pairs, and that the feedback would canvass how the new partnerships worked – or not (Table 3). The questions to which students were responding were:

1. Explain why it is important to work in pairs.
2. How is it to work with somebody new?
3. What difficulties did you find?
4. What ideas have you got in order to improve working with your partner?

In this session (and even more so for the following one), there was a reduction in the number of feedback sheets submitted by PG students. In terms of understanding why they were being paired, undergraduate students were able to identify the benefits of peer-to-peer interaction for their own learning (coded as self-evaluation):

- To gain other insights.
- Having two different views on an area is helpful.
- Accumulate ideas.

- Sharing ideas.
- Able to help fix errors that one has made.

Contrary to the expectations underpinning the design of the subject, it was the undergraduate students who were most frustrated by their new partners' lack of contributions and knowledge. In response to working with someone new, two undergraduates wrote:

- Horrible, they did nothing.
- Hard, you do not know what they are capable of doing or how they think.

One undergraduate suggested that this type of learning needed to be introduced earlier in the course, and another that different levels of experience, motivation and knowledge meant progress was slower. Four undergraduates and one postgraduate mentioned that there was a language barrier to be surmounted.

**Table 3: Students' views of working in pairs**

Q	Issue	UG (PHYS366) (n=11)	PG (PHYS 952) & PHYS 950) (n=4)
1	Performative skills – learn teamwork specifically	5	2
	Performative skills – as related to future work	6	0
	Self-evaluation	5	2
2	Positive: differences can be a resource	5	1
	Generally positive	4	2
	Negative	4	0
	Suggest changed teaching strategies	1	0
3	No particular difficulties	2	1
	Difficulties related to the innovation	1	0
	Technical skills	4	1
	Language barriers	4	1
4	Managing the work within the allocated time	3	2
	Changed teaching/learning strategies	3	0
	Performative skills – collaboration	3	1
	Rejection of the new partner	1	0

It was at this point that our attention turned to the cultural differences between the two groups – all of the undergraduate students were Australians who had already had two years' experience in Australian higher education, and thus a background in interactive problem-solving. These differences appear to affect the teaching improvements they suggested in response to Question 4, and they were certainly recorded by the lecturer in her journal. Whereas the postgraduates sought to try and speed themselves up, increase their levels of patience, or start by clarifying what each person in the pair wanted out of the subject (highly personal goals), the undergraduates suggested that:

- The problem was the international students: 'Try to divide workload but they find a lot of difficulty with most work', 'Get a new one', and '[They should] listen to their partner's ideas';
- Some changed teaching strategies might help, such as increasing the number of demonstrators, or a fun introductory exercise; and
- That higher levels of conversation about what each of them are doing would be helpful.

The lecturer had noted that students were beginning to show some independence as they gained confidence. The starting point, including amongst the postgraduate students, had been that, when they encountered a problem they did even think about a solution, or try to understand the problem, but simply asked the tutor.

### ***The fourth laboratory***

Given students' difficulties in the third laboratory session, the second exercise, to model the radiation field emitted by the radioactive source, had been postponed to the fourth laboratory. This change was manageable because the design of the Geant4 hands-on laboratory had been flexible.

In the original organisation of the course, the final exercise was to consist in an in-depth study of alternative Geant4 electromagnetic approaches to describing the interactions of particles in matter. Students were to learn to activate the alternative models and analyse the effect of the specific physics model sets in the dosimetric results of their Geant4 simulation. Given the difficulties encountered by the students throughout the course, we saw it as unrealistic to expect students to complete this exercise successfully within the specified time schedule. Moreover, students were getting increasingly tired, because this laboratory sequence took place at the end of session.

We decided to simplify the exercise. We explained the physics processes involved in the simulation application, and the exercise consisted of analysing the effect of the threshold of production of secondary particles in the dosimetric results of the simulation.

The lecturer observed in this fourth session that students' confidence was increasing. They were working increasingly independently, but still needed reassurance that what they were doing was correct. In the fifth (additional) session, students had time to finish their exercises, work on their reports and show them to tutors for feedback.

At the conclusion of the session, students were asked to respond to the following statements:

- In this subject, I feel I have done particularly well in...
- If I were to do this subject again under the same conditions, I would probably...
- Is there something that has tweaked your interest with which you want to go further?

Students' responses to these questions are summarised in Table 4.

**Table 4: Students' self-assessments**

Q	Issue	UG (PHYS366) (n=7)	PG (PHYS 952 & PHYS 950) (n=3)
1	Learning programming/maths	3	2
	Learning basic principles of Geant4	3	2
	Pleased with performance	4	0
	Easy to understand anyway	0	1
	Radiation physics-specific comment	0	1
	Nothing	2	0
	The first two lectures	1	0
2	Put in more effort	7	3
	Ask the lectures to focus on physics rather than insignificant issues	0	1
	Try to work with a different partner	1	0
	Finish it in half an hour/it would be easier	2	1
3	See a future for themselves using Geant4	3	3
	Would enjoy experimenting with simulations/doing one solo	2	0
	No/too hard/not interested	4	2
	Don't know	1	0



The majority of students (6 undergraduates and 4 postgraduates) were pleased with their increased grasp of Geant4 and how to use it. One postgraduate student was very specific about their increased capacities ('Changing geometry in DetectorConstruction.cc, also primary generator action'), but other students simply made general comments. Four undergraduates were pleased with their performance (getting out of messes, the mid-session test, writing the report and working well in the group situation). Two undergraduate students did not feel as if they had done particularly well at anything.

In terms of doing the subject again under the same conditions, the majority of students (7 undergraduate and 3 postgraduate) said that they would put in more effort, either through pre-reading, better note-taking, or practicing at home. Two students expressed frustration, the undergraduate with their partner, and the postgraduate with the lack of physics content. Three students said they would find the subject easier, which meant that they felt they had learnt some basic skills.

As to any future involvement, five undergraduates were interested, and five were not; three postgraduates were interested, and two were not. Comments from undergraduate students included:

- I like the concept of Monte Carlo. I would be interested in medical physics, except for possible danger to people. Being able to experiment on a computer, with the same concepts, is great.
- Geant4.
- The simulations themselves would be interesting to mess around with.
- Talking to younger UOW graduates at Wollongong hospital was the first time I felt confident about a career in the degree.

Comments from postgraduates included:

- Yes I want to learn how to use C++ and Geant4 efficiently.
- I found Geant4 very interesting means to go with. So, I'd like to work with new geometries and physics in the future.
- Too hard programming language.

Although the numbers of students providing feedback is small, their views are primarily positive, and indicate that the combined undergraduate/postgraduate approach has promise.

## **Discussion and conclusions**

Successful teaching is a construction site, where activity, interactions and self-monitoring ensure that everything is going to plan (Biggs, 2007, p. 72) – or allow for revisions and readjustments where necessary. The success of this laboratory depended, we thought, on very attentive laboratory staff, to individuate the deficiencies and strengths of each working pair, to make sure that all the pairs worked actively, and to steer the learning process to enhance problem solving skills and critical analysis. Postgraduates would eventually lead the learning about physics, and the likelihood of a learning community based on an increasingly clear relationship between teaching and research would be enhanced.

Our erroneous assumption that all students would have some familiarity with C++ programming language was our first obstacle. Whilst extra classes were arranged to deal with this, students' initial responses to this anxiety-provoking situation may have coloured their view of the learning in which they were engaged, and it is quite possible that the students underestimated what they achieved in such a short period of time. Even though the students' feedback indicated some enthusiasm for using Geant4 in future, during the laboratory sessions they were not particularly enthusiastic. It was particularly disappointing that the experience was largely negative for the undergraduate students, who we had hoped to enthuse by their contact with postgraduates.

Fuhrer (1993), referring to research on group socialisation and on occupational socialisation, looks at the kinds of behaviour evoked in (perilous) new situations. He suggests at least seven responses are possible, including: not knowing what to do; recalling corresponding activities in similar settings; taking actions which place us nearer to or further from our goal; feelings of confusion; self-conscious sensitivity to the impression being made; avoiding the danger of being seen as a non-member of the setting; and embarrassment and anxiety as a consequence of performance deficiencies. In our particular situation, we also faced a cultural divide between undergraduate and postgraduate students. Research suggests that students from Arabic countries (which, in this instance, was our largest group of international students) will:

- look to the teacher to initiate communication;
- thrive in collaborative problem-solving activities;
- benefit from a preparatory phase that reduces anxieties and builds confidence through the provision of technical support and personal introductions;
- be particularly anxious if they lack of technical skills, reducing

confidence in the likelihood of being successful;

- be particularly embarrassed by have nothing much to contribute, as the shame reflects far more broadly on one's family and society than is the case with a more typically Western individualised experience of guilt;
- avoid putting themselves forward, as eagerness to participate is sometimes seen as 'showing off'; and
- benefit from having their capacity to memorise valued.

(Al-Harthi, 2005; Arden-Close, 1999; Bary, 2007; Noer, 2008).

The problems faced by all of our students, then, would seem to relate to an absence of attention to anxiety reduction and fostering collaborative relationships between students in the early stages of the subject – intensive expert guidance is not, in itself, sufficient to overcome cultural and other barriers to active involvement and collaboration. One of the issues is that the focus on fostering the teaching/research nexus, and translating practices from the research laboratory into the undergraduate teaching context, made inclusivity and its role in group formation and development recede into the penumbra.

What we suspect is that the Boyer vision reflects a type of teaching/research context that is disappearing in the global market. Institutional strategies may surprise academics, as Yang (2002) points out: for example, they are unlikely to know about partnership arrangements that result in significant changes in cohort composition in time to adjust their teaching. In Australia, limited numbers of undergraduate students undertake postgraduate studies in the university in which they first studied (indeed, this is often discouraged), and so the strongest bonds, and appreciation of the way the academic game works in a particular institution, lie with undergraduates rather than postgraduates. Then, too, when postgraduate students are international students in transit, have their families with them and are strangers in a strange land, any attempts to build new relationships may be weak, or may be repulsed by local students who feel no need to extend their networks. Thus the potential of diversity to enhance learning may be reduced.

What this means is that a broad notion of research/learning communities as a framework for enhancing the teaching/research nexus has severe limitations; we are now working from the assumption that it is more useful to turn to a familiar array of teaching and learning strategies – attention to group development and processes, recognition of difference and the embedding of supports for learning within the context of the subject (Arkoudis, n.d.; Grace and Gravesend, 2008; Jacques and Salmon, 2007; Rose, 2005). In this instance, what we envisage for the next iteration of the subject includes:

- a pre-lab on Linux and C++ to build up technical skills in a less frustrating way for students and lecturers alike;
- providing some fun introductory activities, to set the climate for effective partnering, leading into the establishment of rules for working together;
- encouraging overseas students in participating in conversational development programs, to increase their capacity to share their ideas, or providing a mandated ancillary program;
- provision of a web page, in the CMRP site, covering documentation on Geant4 and research projects in this domain;
- setting up an e-learning system for the Geant4 hands-on laboratory;
- breaking the first, lengthy session into two sessions, as there is too much content for students to work with effectively at this stage of their learning;
- aiming to foster greater independence in problem-solving by, perhaps, a 'race' among the various teams at the end of the laboratory, giving a problem and who solves it wins.

Given how useful the ongoing feedback processes have been in the current study, these new measures will again be monitored as they are implemented, in an ongoing action research process. There are indications that the combined approach can open students' eyes to the potential of the simulation toolkit for their research and their future employment, and this holds true at undergraduate and postgraduate levels for about half of the participants. In terms of future developments, the potential for this type of approach is being explored with one other university, and the issue of assessment will be the subject of a further paper.

Our work reflects broader concerns about whether universities have been failing their undergraduate populations in terms of fostering their research capacities and building academic and professional futures (Boyer, 1998; Ramsden, 2001), as well as the possibility that the tenor of the debate about the teaching/research nexus is instrumental, individualistic, normative and foundationalist (Trowler and Wareham, 2007). Our experience tends to echo these critiques, from a slightly different angle. Often the teaching/research nexus is considered by teaching experts who are trying to ensure that research has a presence in teaching and that teaching is considered a scholarly activity. In contrast, here the intervention was largely conceptualised in researchers' terms, primarily using accepted models of research practice, supplemented by a broad-based conceptualisation of

learning communities. The inadequacies of these tools were highlighted by the unanticipated composition of the postgraduate cohort. Somewhat ironically, the multi-cultural composition of the teaching/research team had not alerted us to the likely problems.

Despite the difficulties faced by staff and students alike in bringing together these very different student cohorts, lacunae in theory and practical studies (Yang, 2002) mean that this type of study is essential to identifying what needs to be done in classrooms to support the connection between research and teaching (Baldwin, 2005), and to better support international postgraduate students. It is our belief that, however rocky the road in its early stages, linking undergraduate, Honours and postgraduate students with each other through a research process, designed upon sound educational principles rather than assumptions about the nature of research/learning communities, will represent a positive development in teaching, learning, research, professional practice and in teaching internationalised student cohorts. Moreover, the types of processes we believe should be set in place to encourage embedded skill development, cross-cultural communication and group work (Arkoudis, n.d.; Grace and Gravesend, 2008; Jacques and Salmon, 2007; Rose, 2005) would be of value whatever the cohort composition, and across a diverse range of subjects.

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